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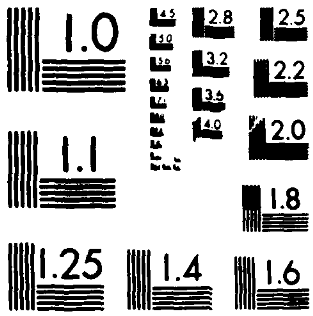

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October 1983

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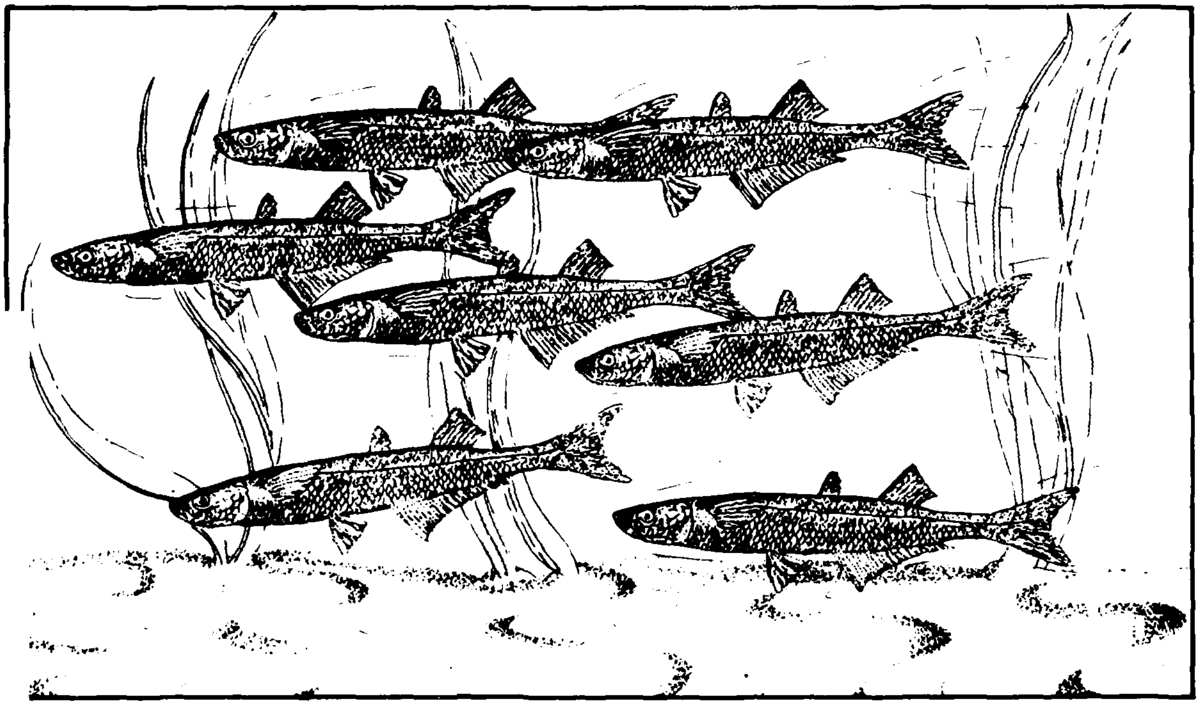
Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)

ATLANTIC SILVERSIDE



Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

Fish and Wildlife Service
U.S. Department of the Interior

FWS/OBS-82/11.10
TR EL-82-4
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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic)

ATLANTIC SILVERSIDE

by

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Waterways Experiment Station

Performed for
National Coastal Ecosystems Team
Division of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

CONVERSION FACTORS

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (gm)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (mt)	2205.0	pounds
metric tons (mt)	1.102	short tons
kilocalories (kcal)	3.968	BTU
Celsius degrees	1.8(C°) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
BTU	0.2520	kilocalories
Fahrenheit degrees	0.5556(F° - 32)	Celsius degrees

CONTENTS

A-1

PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to:

Information Transfer Specialist
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
NASA-Slidell Computer Complex
1010 Gause Boulevard
Slidell, LA 70458

or

U.S. Army Engineer Waterways Experiment Station
Attention: WESER
Post Office Box 631
Vicksburg, MS 39180

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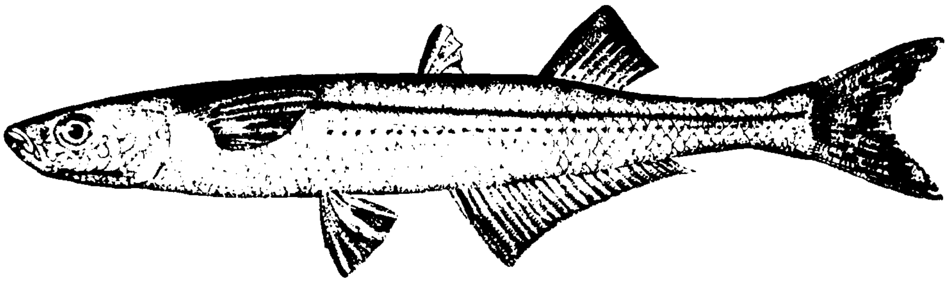

Figure 1. Atlantic silverside.

ATLANTIC SILVERSIDE

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . Menidia menidia
Preferred common name . . Atlantic silverside (Figure 1).
Other common names . . Spearing, sperling, green smelt, sand smelt, white bait, capelin, shiner (Bigelow and Schroeder 1953).
Class . . . . Osteichthyes
Order . . . . Atheriniformes
Family . . . . Atherinidae

Geographical range: Atlantic coast of North America, from just north of 47 degrees north latitude, in New Brunswick, Nova Scotia, and the Magdalen Islands (Gosline 1948), south to Volusia County, Florida (Leim and Scott 1966). Widespread and abundant in coastal waters and tributaries of the entire area (Massmann 1954; Robbins 1969) (see Figure 2 for a map of the mid-Atlantic distribution of Atlantic silverside).

MORPHOLOGY/IDENTIFICATION AIDS

The following information was taken from summaries in Martin and Drewry (1978), where a detailed morphological description is available.

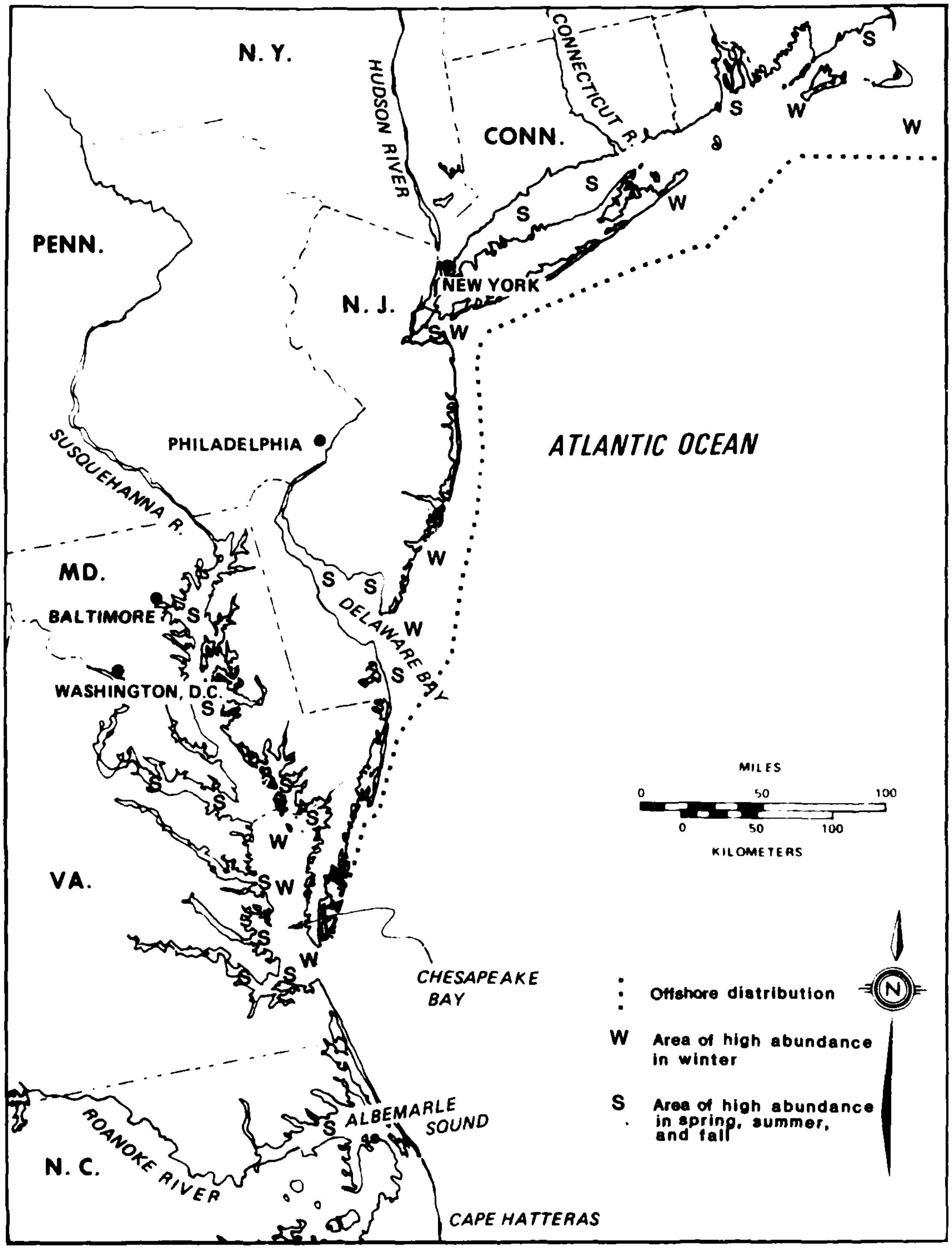

Figure 2. Mid-Atlantic distribution of the Atlantic silverside. The offshore distribution boundary is representative of the majority of Atlantic silverside populations; however, National Marine Fisheries Service (NMFS) trawl surveys have reported Atlantic silversides offshore to 180 km (112 mi) in spring/summer and to 150 km (93 mi) in winter (Conover and Murawski 1982).

Dorsal spines 3-7 (mean 4.6), dorsal rays 7-11 (mean 8.6), anal spines 1, anal rays 19-29 (mean 23.6). Lateral line scales between pectoral insertion and caudal fin 34-47 (mean 40.7).

Body elongate, slender, rounded to dorsally depressed. Head triangular, dorsally flattened; mouth terminal and slightly superior, maxillary not extending to front of eye. Scales cycloid with entire margins, well imbricated.

Color: Dorsally translucent green to greenish-yellow; laterally silver, with well defined, longitudinal, metallically lustered, silver-colored stripe, edged above by dark line; ventrally white. Dorsal and caudal fin rays uniformly spotted, and caudal fin usually tinged with yellow.

REASON FOR INCLUSION IN SERIES

The Atlantic silverside is an important forage fish (Merriman 1941; Bayliff 1950; Bigelow and Schroeder 1953), reaching high abundance in the shore-zone of salt marshes, estuaries and tidal creeks. This species is often the most abundant fish encountered in these areas (Mulkana 1966; Richards and Castagna 1970; Briggs 1975; Anderson et al. 1977; Hillman et al. 1977).

The importance of Atlantic silversides as forage for such piscivores as striped bass (*Morone saxatilis*), Atlantic mackerel (*Scomber scombrus*), and bluefish (*Pomatomus saltatrix*) has been well documented (Bayliff 1950; Bigelow and Schroeder 1953; Schaefer 1970). Presumably then, the Atlantic silverside should be a key member of the estuarine food web, but until recently, little study has been devoted to its life history, particularly environmental requirements (Conover and Ross 1982).

LIFE HISTORY

Reproductive Physiology/Strategy

Atlantic silversides are heterosexual; however, an unusual mechanism of sex determination in this species has been identified. Adult gender is apparently controlled by interaction of female parent genotype with water temperature regime during a specific and critical period of larval development (see LIFE HISTORY--Larvae section) (Conover and Kynard 1981). Reproductive mode varies from polygamy (Middaugh et al. 1981) to extensive promiscuity (Conover 1982).

Both sexes of the Atlantic silverside mature by age 1. Although 2-year-old specimens have been reported (Bayliff 1950; Conover and Ross 1982), apparently most adults die after completion of their first spawning (perhaps because of physiological exhaustion) (Conover and Ross 1982), or are lost to other causes of mortality before they reach age 2. In Essex Bay, Massachusetts, 2-year-old fish constituted 0.2% and 1.0%, respectively, of the 1977 and 1978 spawning populations. Both males and females were represented by 2-year-old individuals (Conover and Ross 1982). Females are larger and heavier than males of the same age (Conover 1982), a fact that may be related to the unusual mechanism of sex determination discussed in the LIFE HISTORY -Larvae section.

Little is known concerning frequency of spawning within a season for an individual silverside. A frequency of four or five times per female per season was reported in Conover (1979). In laboratory studies of spawning activities of female Atlantic silversides in 85-l aquaria,

individual females spawned up to 20 separate times in a season (Conover 1982). The applicability of this spawning frequency to field environments is unknown, since (1) ripe females were placed in test tanks individually, rather than in large schools as in natural environments; (2) spawning periodicity of an individual female was every 1 to 3 days, not coinciding with normal lunar cycles or observed natural spawning periodicity; and (3) no "tide-like" influences were applied in the laboratory tests.

Fecundity of Atlantic silversides ranged from 4,725 to 13,525 total eggs. The average number of eggs actually spawned in a season was 4,500 to 5,000 per female. It was noted that these eggs were probably released in four or five separate spawning events per female per year (Conover 1979). A much lower fecundity estimate, from earlier studies, was an average of 500 eggs (Hildebrand 1922) and a range up to 1,400 eggs (Kendall 1902).

Spawning-General

Atlantic silversides spawn in the intertidal zone of nearly all major estuaries and tributaries within their geographic range (Hildebrand 1922; Wang 1974). Spawning areas are seaward of locations used by Menidia beryllina (inland silverside), a closely related species (Smith 1971). The major spawning season of Atlantic silversides in the mid-Atlantic region extends from late March through June (Nichols 1908; Hildebrand 1922; Middaugh 1981). Ripe females have been collected through July in Massachusetts (Kuntz and Radcliffe 1917; Williams and Shaw 1971) and in Chesapeake Bay (Bayliff 1950; Rasin 1976), at water temperatures between 13° and 30°C (55° and 86°F) (Middaugh and Lempesis 1976). Spawning began at temperatures between 16° and 20° C (61° and 68° F) in South Carolina, over a 3-year-period (Middaugh 1981). Initiation of spawning is probably determined by water temperature, photoperiod, or both (Middaugh and Lempesis 1976), in conjunction with high tide and appropriate lunar phase during the spring months (Middaugh 1981; Conover 1982).

Spawning Periodicity

Menidia menidia is one of over 50 fish species known to have lunar-related spawning cycles (Johannes 1978; Conover 1982). Spawning occurs strictly during daylight hours in large schools, and coincides with high tide (Middaugh 1981). The first spawning activity usually occurs at a new or full moon in early spring, and is followed by spawning peaks at approximately 14- (Conover 1982) or 15-day (Middaugh 1981) intervals. Some spawning activity was observed on days other than those of new or full moon (Middaugh 1981), but up to 90% of the spawning within each 14- to 15-day stratum occurred over 1- (Conover 1982) to 3-day (Middaugh 1981) periods. Some differences in spawning periodicity between South Carolina and Massachusetts populations of Atlantic silverside have been reported. Conover (1982) concluded that spawning periodicity in Massachusetts was highly correlated to the lunar phase, and that spawning intensity was dependent on relative height of a given high tide. In contrast, Middaugh (1981) found that the greatest correlation in South Carolina populations was between spawning periodicity and the coincidental occurrence of sunrise and high tide, approximately every 15 days. Days of high tide at sunrise also coincided fairly closely with new and full lunar phases during spring months. Regardless, the periodicity-lunar phase correlation was not as high as the periodicity-sunrise and high tide correlation in the South Carolina population. Additionally, relative height of the high tide was not correlated with spawning

intensity (Middaugh 1981). During spring high tides, the greatest spawning intensity was observed at the slack (Middaugh 1981) or ebbing (Conover 1982) stages. It is apparent from studies of Atlantic silverside spawning periodicity that specific mechanisms and adaptive significance of lunar-related spawning cycles are poorly understood (Conover 1982).

Spawning Behavior

Middaugh et al. (1981) described spawning behavior of Atlantic silversides in South Carolina. One-half to 1 hour prior to a spawn, a single large school or several smaller schools of adults appeared 10 to 30 m (33 to 98 ft) offshore, adjacent to the eventual spawning site. Schools swam parallel to shore, gradually moving shoreward with the flood stage until the leading edge of the school was 2 to 3 m (6 to 10 ft) from shore. Positions in relation to shore and swimming speed of the school were maintained until just before peak high tide, when several individuals moved suddenly into flooded shoreline vegetation, followed by the remainder of the spawning school. Eggs were released as a female crossed the axis of a potential attachment substrate such as a cordgrass plant. One to several males followed closely and deposited milt. Several variations on this general behavioral pattern were described in Middaugh et al. (1981) and Conover (1982), including spawning in abandoned fiddler crab (Uca pugilator) burrows.

Dissolved Oxygen Depletion (Spawning)

Middaugh (1981) and Middaugh et al. (1981) found that extremely high spawning densities, commonly observed during peak Atlantic silverside spawning episodes, temporarily depleted dissolved oxygen concentrations in the immediate area of the most intense spawning activity. Dissolved oxygen isopleths coincided closely with density gradients of spawning fish within a school. In an unusually intense spawning event on 30 April 1976, dissolved oxygen dropped from 6 mg/l to 0.7 mg/l in the center of the spawning mass.

An interesting consequence of this dissolved oxygen depletion was reported (Middaugh 1981). Predators such as small bluefish and spotted seatrout (Cynoscion nebulosus), surrounding spawning schools of Atlantic silversides, were unable to penetrate past the 4.0 mg/l and 2.5 mg/l dissolved oxygen isopleths, respectively. This apparently limited or prevented predation on the heaviest concentrations of Atlantic silversides during the time of peak spawning (Middaugh 1981). The oxygen depletion in combination with the energy drain associated with spawning appeared to affect the spent silversides (Middaugh 1981). Spent fish from intense spawning events were observed offshore from spawning beds in tight but nonschooling aggregations, and appeared to be stuporous and in a state of physiological recovery. These stuporous aggregations could be approached by man, and presumably by predators, with relative ease.

Eggs

Eggs of the Atlantic silverside generally range from 0.9 to 1.2 mm[1] in diameter (Wang 1974; Middaugh 1981), though diameters up to 1.5 mm have been reported (Tracy 1910; Leim and Scott 1966). Eggs are transparent, yellow to green, and have 5 to 12 large oil globules and numerous small globules (Kuntz and Radcliffe 1917; Hildebrand 1922). Eggs are demersal, adhesive, and found in shallow waters of estuarine intertidal zones (Kuntz and Radcliffe 1917; Hildebrand 1922; Middaugh 1981).

Substrates for egg attachment are submerged vegetation (Bayliff 1950), particularly eelgrass (Middaugh 1981),

[1]25.4 mm = 1 inch.

cordgrass (Middaugh et al. 1981), and filamentous algae (Conover 1982). Sand (Wang 1974) and beach trash (Nichols 1908) may also harbor attached eggs. Studies in Salem Harbor, Massachusetts, indicated that egg attachment substrates there were more specific than those described for other silverside populations. Only algal mats of the filamentous brown algae *Pilayella littoralis* and *Entermorpha* spp. were used, even though these algae were growing among various aquatic vascular plants such as *Spartina alterniflora* (Conover 1982).

Egg attachment is reinforced by several filaments (Hildebrand 1922; Middaugh 1981; Conover 1982) originating from a specific area of the chorion (Kuntz and Radcliffe 1917; Wang 1974), which uncoil upon oviposition (Ryder 1883; Hildebrand 1922). Filaments are usually from five (Middaugh 1981) to eight (Ryder 1883) times the egg diameter in length. Eggs may also adhere to each other in clusters (Hildebrand 1922; Leim and Scott 1966).

Incubation time for Atlantic silverside eggs was 3 days at 30°C (86° F), 5 days at 25°C (77°F), 10 days at 20°C (68°F), 15 days at 18°C (64°F), and 27 days at 15°C (59°F) (Costello et al. 1957; Austin et al. 1975). An equation for predicting incubation time from water temperature, calculated from data in Austin et al. (1975) by Martin and Drewry (1978), is:

$$\log(t) = 2.2672 - 0.0623(T)$$

where t = time in days and T = incubation temperature in degrees C.

Middaugh (1981) found that maximum egg abundance in South Carolina waters occurred at depths of 1.6 to 2.2 m (5.3 to 7.2 ft) below the mean low water (low tide) line. Embryo viability was also highest in this depth range, though a statistically significant correlation between embryo viability and depth of embryo location was not indicated.

Yolk-Sac Larvae

Atlantic silverside yolk-sac larvae range from 3.8 to 5.0 mm total length (TL) at hatching (Wang 1974). The proportion of the original yolk-sac remaining at hatching depends on incubation temperature; a defined yolk-sac is absent when eggs are incubated at 25° C (77° F) or less (Bayliff 1950; Austin et al. 1975). Remaining yolk is absorbed 2 (Middaugh and Lempesis 1976) to 5 (Rubinoff 1958) days after hatching. Yolk-sac larvae are transparent with pigmented eyes at hatching (Hildebrand 1922; Middaugh and Lempesis 1976). Middaugh (1981) found that larval hatching occurred primarily at night during high tides, and suggested that decreased predation may be a benefit of nocturnal emergence.

Larvae

Atlantic silverside larvae range from 5.5 to 15.0 mm TL (Wang 1974). Both yolk-sac larvae and larvae have a notably forward anus, rarely farther behind the snout than one-fourth of the total larval length (Martin and Drewry 1978). Size at transformation to the juvenile stage is not established, but transformation occurs before 20 mm TL (Wang 1974) and is complete when the anus has migrated back along the ventral surface of the body to the approximate midpoint (Hildebrand 1922).

An unusual method of sex determination during the larval stage of Atlantic silversides was demonstrated in a series of laboratory experiments by Conover and Kynard (1981). Larvae subjected to a "cold fluctuating" temperature regime similar to temperatures experienced by larvae in May, between 11° and 19°C (52° and 66°F), produced more females than males. In contrast, a "warm fluctuating"

temperature regime similar to temperatures experienced by larvae in July, between 17° and 25°C (63° and 77°F), produced significantly more males than females. Further, it was determined that the mechanism of sex determination was not by selective egg or larval mortality, but rather the temperature regime experienced by larvae during a critical period, which was between 32 and 46 days after hatching. The water temperature regime experienced by larvae at that stage of development determined whether mostly males or females developed (Conover and Kynard 1981). These laboratory findings were corroborated by examination of sex ratios in natural populations (Essex Bay, Massachusetts) over time (Conover 1982).

Dovel (1971) reported that Atlantic silverside larvae were present throughout low salinity areas of upper Chesapeake Bay, from April through December. Larvae were most abundant in surface waters (< 3 m, < 10 ft) and at salinities of 8 or 9 ppt. Some larvae were found in waters where salinities ranged from 1 to 14 ppt and water temperatures from 12° to 30°C (54° to 86°F). In the Mystic River Estuary, Connecticut, Atlantic silverside larvae were found primarily in upper estuarine zones and marshes, where the salinity profile ranged from 2 ppt at the surface to 14 ppt at 2 m (6 ft) depth. All larvae were collected in May and June and ranged from 5.2 to 7.5 mm TL (Pearcy and Richards 1962).

Juveniles/Adults

Juvenile Atlantic silversides range in size from about 20 mm TL (Wang 1974) to approximately 91 mm TL (males) or 98 mm TL (females) (Leim and Scott 1966; Conover and Ross 1982). The juvenile stage lasts from the completion of anal vent migration along the ventral midline (Martin and Drewry 1978) to cessation of growth in late fall (Conover 1982). Smaller juveniles select habitats over vegetated substrates more often than the sand and gravel substrates selected by larger juveniles and adults (Briggs and O'Conner 1971).

Juvenile and adult Atlantic silversides inhabit intertidal creeks, marshes, and shore zones of bays and estuaries in spring, summer, and fall (Hildebrand and Schroeder 1928; Bigelow and Schroeder 1953). Temporal variation in local abundance, probably due in part to fish movements in relation to tidal patterns, has been reported (Merriman 1947; Shenker and Dean 1979; Conover 1982; Conover and Ross 1982). During spring, summer, and fall, Atlantic silversides have often been reported as the most abundant species in marsh and estuarine habitats (Pearcy and Richards 1962; Mulkana 1966; Richards and Castagna 1970; Briggs 1975; Anderson et al. 1977), yet they may be entirely absent from the same areas during winter (Bayliff 1950; Hoff and Ibara 1977; Conover 1982; Conover and Ross 1982).

Geographic variability exists with the winter ecology and habitat of adult Atlantic silversides (Conover and Murawski 1982). In populations from Chesapeake Bay northward, Atlantic silversides are rare or absent from shore zones or shallow waters in midwinter (Bayliff 1950; Hoff and Ibara 1977; Conover and Ross 1982). Richards and Castagna (1970) reported that adult Atlantic silversides were captured in midwinter with bottom trawls in deepwater areas of Chesapeake Bay and estuarine channels along eastern Virginia. Winter catches of adults out to 15 km (9.3 mi) (Clark et al. 1969; Fahay 1975) and 170 km (105.6 mi) (Conover and Murawski 1982) offshore have been reported. In South Carolina tidal creeks, however, adults were present in high abundance throughout winter (Cain and Dean 1976; Shenker and Dean 1979).

National Marine Fisheries Service (NMFS) survey data, collected with bottom trawls from Cape Cod, Massachusetts, to Cape Hatteras, North Carolina, was summarized by Conover and Murawski (1982). From 1972 to 1979 (data pooled), percent frequency of occurrence (number of stations captured divided by number of stations surveyed) of Atlantic silversides in depth strata, between 5 and 27 m (16 and 89 ft), peaked in January (34.3%). Atlantic silversides also occurred in March (21.4%), April (9.6%), and November (4.9%). Depth strata from 5 to 27 m were not sampled in February. At depth strata between 27 and 366 m (89 and 1,200 ft) (1963 to 1979, data pooled), percent frequency of occurrence peaked in February (11.2%), and dropped off in March (4.3%) and April (1.5%). The majority (86%) of all Atlantic silversides captured in the NMFS surveys were at depths less than 50 m (164 ft) and water temperatures between 2° and 6°C (36° and 43°F) (Conover and Murawski 1982).

Comparison of winter catch rates during different times of the day indicated that overwintering Atlantic silversides may migrate vertically in the water column during twilight periods. Consistently higher numbers of silversides were captured during the day with bottom trawls than at night in the same overwintering areas (Conover and Murawski 1982).

Biochemical characteristics (through electrophoresis) of Atlantic silverside stocks (Morgan and Ulanowicz 1976) and the genus Menidia (Johnson 1975) have been described. The applicability of such information for separation of stocks and apparent subspecies of Menidia menidia (M. m. menidia, southern subspecies, and M. m. notata, northern subspecies) is discussed in Morgan and Ulanowicz (1976).

GROWTH CHARACTERISTICS

Growth of young-of-the-year Atlantic silversides from hatching to mid-autumn was 10-15 mm/month in Long Island Sound (Austin et al. 1973), 7-14 mm/month in a Rhode Island estuary (Mulkana 1966), and 20 mm/month in Essex Bay, Massachusetts (Conover and Ross 1982). Young-of-the-year males attained 91.5 mm and 3.9 g by November in Essex Bay, and females attained 98.0 mm and 4.8 g (Conover and Ross 1982). Growth of Atlantic silversides virtually ceases between November and March, at least in areas where winter offshore migrations occur (Bayliff 1950; Bigelow and Schroeder 1953; Conover 1982; Conover and Ross 1982).

Condition factor of young-of-the-year Atlantic silversides in Essex Bay, Massachusetts, dropped significantly between September and November for the large 1976 year class, but not for the less abundant 1977 year class (Conover and Ross 1982). For both year classes, the condition factor remained stable through winter, increasing in April and May of the following spring. Conover and Ross (1982) suggested that the 1976 year class may have exceeded the carrying capacity of the Essex Bay nursery area, resulting in the observed reduction in condition during late stages of the growing season (October and November).

Growth rates of age 1+ male Atlantic silversides in Essex Bay averaged 5.8 mm/month and 1.1 g/month over the period 6 May to 5 November. Females grew 5.5 mm/month and 1.4 g/month over the same period. By 5 November, mean lengths and weights of female Atlantic silversides exceeded values for males by 10 mm and 2.9 g (Conover and Ross 1982).

THE FISHERY

Commercial and Recreational Fisheries

Commercial or recreational fisheries for Atlantic silversides are not documented. The authors have observed a small and scattered commercial bait fishery for Atlantic silversides using minnow traps or small seines. Such localized bait fisheries probably have little if any impact on Atlantic silverside populations.

Population Dynamics

In general, the Atlantic silverside is a short-lived species. Two-year-old fish have been reported (Bayliff 1950; Conover and Ross 1982), but the majority of estuarine populations of Atlantic silversides in spring, summer, and fall are juveniles (age 0+) and age 1 adults (Conover and Murawski 1982).

Abundance of the 1977 year class of silverside juveniles in Essex Bay, Massachusetts, in late October and early November (data pooled) was estimated at 1.88 ± 1.16/m^2 (95% confidence limits). Mean biomass of juveniles peaked in late October and early November at 7.8 ± 2.8 g/m^2. Adult densities on spawning grounds the next spring (1978) were estimated at 0.009 ± 0.002/m^2, indicating a total overwintering mortality rate of 99% (Conover and Ross 1982). Conover and Ross (1982) examined Atlantic silverside mortality estimates from other coastal areas of Massachusetts and found that overwintering mortality averaged 97% north of Cape Cod and 88% south and west of Cape Cod. Similarly high overwintering mortality was reported by Warfel and Merriman (1944) in Connecticut, Bayliff (1950) in Chesapeake Bay, and Austin et al. (1973) in New York.

Conover and Ross (1982) also found that overwintering mortality of Atlantic silversides was selective against larger fish, and total mortality was negatively related to mean size and condition of the juvenile year class prior to winter migration. They suggested that, since densities of adults returning the following spring were similar regardless of the fall population size, a density compensatory mechanism of overwintering mortality may occur in Atlantic silverside populations.

Conover (1982) demonstrated that sex ratios of Atlantic silversides in Essex Bay, Massachusetts, fluctuated seasonally, partly because of the unusual mechanism of sex determination described for this species (Conover and Kynard 1981) (see LIFE HISTORY-- Larvae section). Sex ratios in July and August consistently favored females, while sex ratios in September (year-class recruitment complete), October, and November favored males. Sex ratios on the spawning grounds the following spring either favored females (1978) or were not significantly different from 1:1 (1976, 1977).

ECOLOGICAL ROLE

Food Habits/Feeding Behavior

Information about larval food habits, feeding behavior, and daily ration is not available. Juvenile and adult Atlantic silversides are opportunistic omnivores. Food items consumed include copepods, mysids, amphipods, cladocerans, fish eggs, squid, worms, molluscan larvae, insects, algae, diatoms, and detritus (Bigelow and Schroeder 1953; Leim and Scott 1966; Thomson et al. 1971).

Atlantic silversides feed in large schools, often following the tidal ebb and flow along feeding areas. Common feeding areas include gravel and sand

bars, open beaches, tidal creeks, river mouths and flooded zones of marsh vegetation (Bayliff 1950; Bigelow and Schroeder 1953). Information about feeding periodicity is not available.

In laboratory tests, unfed larvae and larvae fed for the first time on day 4 all died by day 6. Survival of larvae fed at the end of day 2 varied with salinity. At 20 ppt, all larvae were dead by day 8, while at 30 ppt, 40% survived through day 14 (Midduagh and Lempesis 1976).

Predators

Atlantic silversides are important forage for such gamefish as striped bass, Atlantic mackerel, and bluefish (Bayliff 1950; Bigelow and Schroeder 1953; Schaefer 1970). Other fish species, egrets, terns, gulls, cormorants, and blue crabs (Callinectes sapidus) also prey on spawning schools of Atlantic silversides (Middaugh 1981). Blue crabs, ruddy turnstones (Arenaria interpres morinella), semipalmated sandpipers (Ereunetes pusillus), and in particular, mummichogs (Fundulus heteroclitus), may prey on eggs and larvae of Atlantic silversides (Middaugh 1981; Conover 1982).

Competitors

Definitive studies of competitive interactions between Atlantic silversides and other species are lacking. Some competition with the closely related inland silverside (Menidia beryllina) may occur, although these two atherinids appear to be spatially separated in many areas. The Atlantic silverside generally selects habitats more seaward than those of the inland silverside (Robbins 1969).

Role as Estuarine Biomass Exporter

Conover and Murawski (1982) demonstrated that age 0^+ Atlantic silversides migrate to offshore waters during late fall. Numbers of age 1 adults returning the following spring indicated very high overwintering mortality (99%). Few if any age 1 fish make it to age 2; most age 1 fish die after spawning or during their second winter of life. This essentially annual life cycle, with high mortality offshore, suggests that Atlantic silversides are important exporters of secondary production and biomass from marsh and estuarine systems to offshore areas (Conover and Murawski 1982).

ENVIRONMENTAL REQUIREMENTS

Temperature

Eggs of Atlantic silverside tolerated water temperatures as low as 15° C (59° F), but larvae that hatched died within 24 hr unless warmer water was located (Austin et al. 1975). Temperatures as high as 30°C (86°F) were also tolerated by eggs. Visible yolk was present upon hatching in 20% of the larvae reared at 30°C, but was absent in larvae hatched at 25°C (77° F) or less (Austin et al. 1975). Optimum temperatures for hatching of eggs have not been determined.

Thermal shock of an 8°C (14°F) increase produced no mortality of Atlantic silverside larvae reared at 17 and 20°C (63° and 68°F), 19% mortality at 25°C (77°F), and 11% mortality at 30°C (86°F) Thermal shock of a 14° C (25° F) increase produced 3% mortality of larvae reared at 17°C (63° F), 0% at 20°C (68°F), and 100% at 25° and 30° C (77° and 86°F) (Austin et al. 1975). Austin et al. (1975) concluded that, since Atlantic silverside larvae would be present in Long Island Sound at seasonal temperatures between 15° and 20°C (59° and 68°F), the larval population would experience minimal stress from nuclear powerplant development on Long Island.

Juvenile Atlantic silversides tolerated water temperatures between 3° and 31°C (37° and 88°F), and preferred a temperature range of 18° to 25° C (64° to 77°F) in upper Chesapeake Bay during summer and fall (Dovel 1971). Juveniles and adults acclimated to 6°C (43°F) and 8°C (46°F), however, preferred water temperatures of 15°C (59°F) (Meldrim and Gift 1971). In general, avoidance behavior of juveniles and adults was observed when test temperatures were 11° to 14°C (20° to 25°F) higher than the acclimation temperature (Meldrim and Gift 1971). Pearce (1969) reported an upper lethal temperature of 32.0°C (90°F) for Atlantic silversides collected from the Cape Cod Canal, Massachusetts. Critical thermal maxima (defined as the temperature at which opercular movements ceased for 30 seconds) for Atlantic silversides collected from the Patuxent River, Maryland, were 30.5°C (87°F) and 33.8°C (93°F) for acclimation temperatures of 5°C (41°F) and 15°C (59°F), respectively (Hall et al. 1982). Atlantic silversides exposed to three different fluctuating temperature regimes, between 5°C and 15°C, exhibited critical thermal maxima intermediate to the above values (Hall et al. 1982). Lower and upper 48-hr median tolerance limits (TLM, the temperature at which 50% of test fish died by 48 hr) were determined by Hoff and Westman (1966) for a range of acclimation temperatures. The lower TLM values for acclimation temperatures of 7°, 14°, 21°, and 28° C (45°, 57°, 70°, and 82°F) were 1.5 2°, 5°, and 9.5°C (35°, 36°, 41°, and 49°F), respectively. Upper TLM values for the same four acclimation temperatures were 22°, 26°, 30°, and 32°C (72°, 79°, 86°, and 90°F), respectively (Hoff and Westman 1966).

Salinity

In laboratory tests, hatching was delayed 18 hr at 20 ppt salinity and 42 hr at 10 ppt, compared to hatching time at 30 ppt (incubation temperature was 21.1°C or 70°F). Percentage hatch was also reduced at salinities below 30 ppt, and optimum salinity for hatching was 30 ppt. Survival of larvae through 14 days was approximately 77% at 30 ppt compared to only 23% at 20 ppt. Growth rate of larvae through day 14 was lower at 20 ppt compared to 30 ppt (Middaugh and Lempesis 1976). Juvenile and adult Atlantic silversides tolerated salinities from freshwater (Tagatz and Dudley 1961; Tagatz 1967) to 37.8 ppt (Tagatz and Dudley 1961). Juveniles were captured from upper Chesapeake Bay in salinities from 1 to 14 ppt, but preferred 7 to 8 ppt (Dovel 1971).

LITERATURE CITED

Anderson, W. D., J. K. Dias, D. M. Cupka, and N. A. Chamerlain. 1977. The macrofauna of the surf zone off Folly Beach, South Carolina. NOAA Tech. Rep. NMFS SSRF-704. 23 pp.

Austin, H. M., J. Dickinson, and C. R. Hickey. 1973. An ecological study of the ichthyofauna at the Northport Power Station, Long Island, New York. Publ. Long Island Lighting Co., Hicksville, N. Y. 248 pp.

Austin, H. M., A. D. Sosnow, and C. R. Hickey. 1975. The effects of temperature on the development and survival of the eggs and larvae of the Atlantic silverside. Trans. Am. Fish. Soc. 104: 762-765.

Bayliff, W. H. 1950. The life history of the silverside, Menidia menidia. Chesapeake Biol. Lab. Publ. 90. 27 pp.

Bigelow, H. B., and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. U. S. Fish Wildl. Serv. Fish. Bull. 53. 577 pp.

Briggs, P. T. 1975. Shore-zone fishes of the vicinity of Fire Island Inlet, Great South Bay, New York. N. Y. Fish Game J. 22:1-7.

Briggs, P. T., and J. S. O'Conner. 1971. Comparison of shore-zone fishes over naturally vegetated and sand-filled bottoms in Great South Bay. N. Y. Fish Game J. 18: 15-41.

Cain, R. L., and J. M. Dean. 1976. Annual occurrence, abundance and diversity of fish in a South Carolina intertidal creek. Mar. Biol. 36: 370-379.

Clark, J., W. G. Smith, A. W. Kendall, Jr., and M. P. Fahay. 1969. Studies of estuarine dependence of Atlantic coastal fishes. U. S. Bur. Sport Fish. Wildl. Tech. Pap. 28. 132 pp.

Conover, D. O. 1979. Density, growth, production, and fecundity of the Atlantic silverside, Menidia menidia, in a central New England estuary. M.S. Thesis. University of Massachusetts, Amherst. 59 pp.

Conover, D. O. 1982. Seasonal migration, reproductive strategy, and environmental sex determination, and its adaptive significance in the Atlantic silverside. Ph.D. Thesis. University of Massachusetts, Amherst. 109 pp.

Conover, D. O., and B. E. Kynard. 1981. Environmental sex determination: interaction of temperature and genotype in a fish. Science 213: 577-579.

Conover, D. O., and S. A. Murawski. 1982. Offshore winter migration of the Atlantic silverside. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 80: 145-150.

Conover, D. O., and M. R. Ross. 1982. Patterns in seasonal abundance, growth, and biomass of the Atlantic silverside in a New England estuary. Estuaries 5: 275-286.

Costello, D. P., M. E. Davidson, and A. Eggers. 1957. Methods for obtaining and handling marine eggs and embryos. Mar. Biol. Lab., Woods Hole, Mass. 247 pp.

Dovel, W. L. 1971. Fish eggs and larvae of the upper Chesapeake Bay. Univ. Md. Nat. Resour.

Inst. Spec. Rep. 4. 71 pp.

Fahay, M. P. 1975. An annotated list of larval and juvenile fishes captured with surface-towed meter nets in the South Atlantic Bight during four RV Dolphin cruises between May, 1967 and February, 1973. NOAA Tech. Rep. NMFS SSRF-685. 39 pp.

Gosline, W. A. 1948. Speciation in the fishes of the genus Menidia. Evolution 2: 306-313.

Hall, L. W., Jr., D. T. Burton, and P. R. Abell. 1982. Thermal response of Atlantic silversides (Menidia menidia) acclimated to constant and asymmetric fluctuating temperatures. Arch. Hydrobiol. 94: 318-325.

Hildebrand, S. F. 1922. Notes on habits and development of eggs and larvae of the silversides, Menidia menidia and M. beryllina. U. S. Bur. Fish. Bull. 38: 113-120.

Hildebrand, S. F., and W. C. Schroeder. 1928. Fishes of Chesapeake Bay. U. S. Bur. Fish. Bull. 43. 388 pp.

Hillman, R. E., N. W. Davis, and J. Wennemer. 1977. Abundance, diversity, and stability in shore-zone fish communities in an area of Long Island Sound affected by the thermal discharge of a nuclear power station. Estuarine Coastal Mar. Sci. 5: 355-381.

Hoff, J. G., and R. M. Ibara. 1977. Factors affecting the seasonal abundance, composition and diversity of fishes in a southeastern New England estuary. Estuarine Coastal Mar. Sci. 5: 665-678.

Hoff, J. G., and J. R. Westman. 1966. The temperature tolerances of three species of marine fishes. J. Mar. Res. 24(2): 131-139.

Johannes, R. E. 1978. Reproductive strategies of coastal marine fishes in the tropics. Environ. Biol. Fishes 3: 65-84.

Johnson, M. S. 1975. Biochemical systematics of the Atherinid genus Menidia. Copeia 1975: 662-691.

Kendall, W. C. 1902. Notes on the silversides of the genus Menidia of the east coast of the United States, with descriptions of two new subspecies. Rep. U. S. Fish. Comm. (1901): 241-267.

Kuntz, A., and L. Radcliffe. 1917. Notes on the embryology and larval development of twelve teleostean fishes. U. S. Bur. Fish. Bull. 34: 407-429.

Leim, A. H., and W. B. Scott. 1966. Fishes of the Atlantic coast of Canada. Fish. Res. Board Can. Bull. 155: 1-485.

Martin, F. D., and G. E. Drewry. 1978. Development of fishes of the mid-Atlantic Bight, Volume VI. U. S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-78/12. 416 pp.

Massmann, W. H. 1954. Marine fishes in fresh and brackish waters of Virginia ·ivers. Ecology 35: 75-78.

Meldrim, J. W., and J. J. Gift. 1971. Temperature preference, avoidance and shock experiments with estuarine fishes. Ichthyol. Assoc. Bull. 7. 75 pp.

Merriman, D. 1941. Studies on striped bass of the Atlantic coast. U. S. Fish Wildl. Serv. Fish. Bull. 50: 1-77.

Merriman, D. 1947. Notes on the midsummer ichthyofauna of a Connecticut beach at different tide levels. Copeia 1947: 281-286.

Middaugh, D. P. 1981. Reproductive ecology and spawning periodicity of the Atlantic silverside. Copeia 1981: 766-776.

Middaugh, D. P., and P. W. Lempesis. 1976. Laboratory spawning and rearing of a marine fish, the silverside Menidia menidia menidia. Mar. Biol. 35: 295-300.

Middaugh, D. P., G. I. Scott, and J. M. Dean. 1981. Reproductive behavior of the Atlantic silverside. Environ. Biol. Fishes 6: 269-276.

Morgan, R. P., II, and N. I. Ulanowicz. 1976. The frequency of muscle protein polymorphism in Menidia menidia along the Atlantic coast. Copeia 1976: 356-360.

Mulkana, M. S. 1966. The growth and feeding habits of juvenile fishes in two Rhode Island estuaries. Gulf Res. Rep. 2: 97-168.

Nichols, J. T. 1908. A note on the silverside. Am. Nat. 42: 731.

Pearce, J. B. 1969. Thermal addition and the benthos, Cape Cod Canal. Chesapeake Sci. 10: 227-233.

Pearcy, W. G., and S. W. Richards. 1962. Distribution and ecology of fishes of the Mystic River Estuary, Connecticut. Ecology 43: 248-259.

Rasin, V. J. 1976. Spawning and larval fish in the Potomac Estuary. Pages 95-99 in The Potomac Estuary, trends and options. Proc. Symp. Md. Dep. Nat. Resour., 1975, Alexandria, Va.

Richards, C. E., and M. Castagna. 1970. Marine fishes of Virginia's eastern shore (inlet and marsh, seaside waters). Chesapeake Sci. 11: 235-248.

Robbins, T. W. 1969. A systematic study of the silversides. Ph.D. Thesis. Cornell University, Ithaca, N. Y. 281 pp.

Rubinoff, I. 1958. Raising the Atherinid fish, Menidia menidia, in the laboratory. Copeia 1958: 146-147.

Ryder, J. A. 1883. On the thread bearing eggs of the silversides. U. S. Fish. Comm. Bull. 3: 193-196.

Schaefer, R. H. 1970. Feeding habits of striped bass from the surf waters of Long Island. N. Y. Fish Game J. 17: 1-17.

Shenker, J. M., and J. M. Dean. 1979. The utilization of an intertidal salt marsh creek by larval and juvenile fishes: abundance, diversity and temporal variation. Estuaries 2(3): 154-163.

Smith, B. A. 1971. An ecological study of the Delaware River in the vicinity of Artificial Island. Part V of The fish of four low-salinity tidal tributaries of the Delaware River Estuary. Ichthyol. Assoc. Rep. Publ. Serv. Electric and Gas Co., Ithaca, N. Y. 291 pp.

Tagatz, M. E. 1967. Fishes of the St. Johns River, Florida. J. Fla. Acad. Sci. 30(1): 25-50.

Tagatz, M. E., and D. L. Dudley. 1961. Seasonal occurrence of marine fishes in four shore habitats near Beaufort, North Carolina, 1957-1960. U. S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 390. 19 pp.

Thomson, K. S., W. H. Weed III, and A. G. Taruski. 1971. Salt-water fishes of Connecticut. Conn. State Geol. Hist. Surv. Bull. 105. 165 pp.

Tracy, H. C. 1910. Annotated list of the fishes known to inhabit the waters of Rhode Island. Annu. Rep. R. I. Comm. Inland Fish. 40: 35-176.

Wang, J. C. S. 1974. Atherinidae---silversides. Pages 143-151 *in* A. J. Lippson and R. L. Moran, eds. Manual for identification of early developmental stages of fishes of the Potomac River Estuary. Md. Dep. Nat. Resour. Power Plant Siting Program. PPSP-MP-13. 282 pp.

Warfel, H. E., and D. Merriman. 1944. Studies on the marine resources of south New England. Bull. Bingham Oceanogr. Collect. Yale Univ. 9: 1-91.

Williams, M. M., and E. Shaw. 1971. Modifiability of schooling behavior in fishes: the role of early experience. Am. Mus. Novit. 2448: 1-19.

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16. Abstract (Limit: 200 words)

Species profiles are literature summaries of the taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are prepared to assist in environmental impact assessment. The Atlantic silverside (Menidia menidia) is an important link in estuarine food webs as an opportunistic omnivore and as forage for large piscivores such as striped bass (Morone saxatilis) and bluefish (Pomatomus saltatrix). Many times the Atlantic silverside is the most abundant fish species encountered in estuaries and tributaries. They mature at age 1 and spawn in the intertidal zone of estuaries from March to June in the mid-Atlantic region. Few 2-year-old fish are ever encountered, so the Atlantic silverside is basically a short-lived species. Most spawning occurs at high tide during new or full moon phases. Eggs are adhesive and are found attached to submerged vegetation. Larvae, juveniles, and adults generally inhabit similar areas. Sex is determined in larval development 32 to 46 days after hatching, and is a function of parental genotype and water temperature regime during the critical period. Fisheries for this species are not documented. Eggs can tolerate water temperatures between 15° and 30°C, and larvae need temperatures above 15°C for survival. Larvae tolerate relatively acute temperature increases. Upper lethal temperatures for juveniles and adults range from 30.5° to 33.8°C, depending on acclimation temperature. Salinities of 20 ppt or lower significantly delay hatching and affect larval survival. Juveniles and adults tolerate the full range of naturally occurring salinities (i.e., freshwater to at least 37.8 ppt). Keywords:

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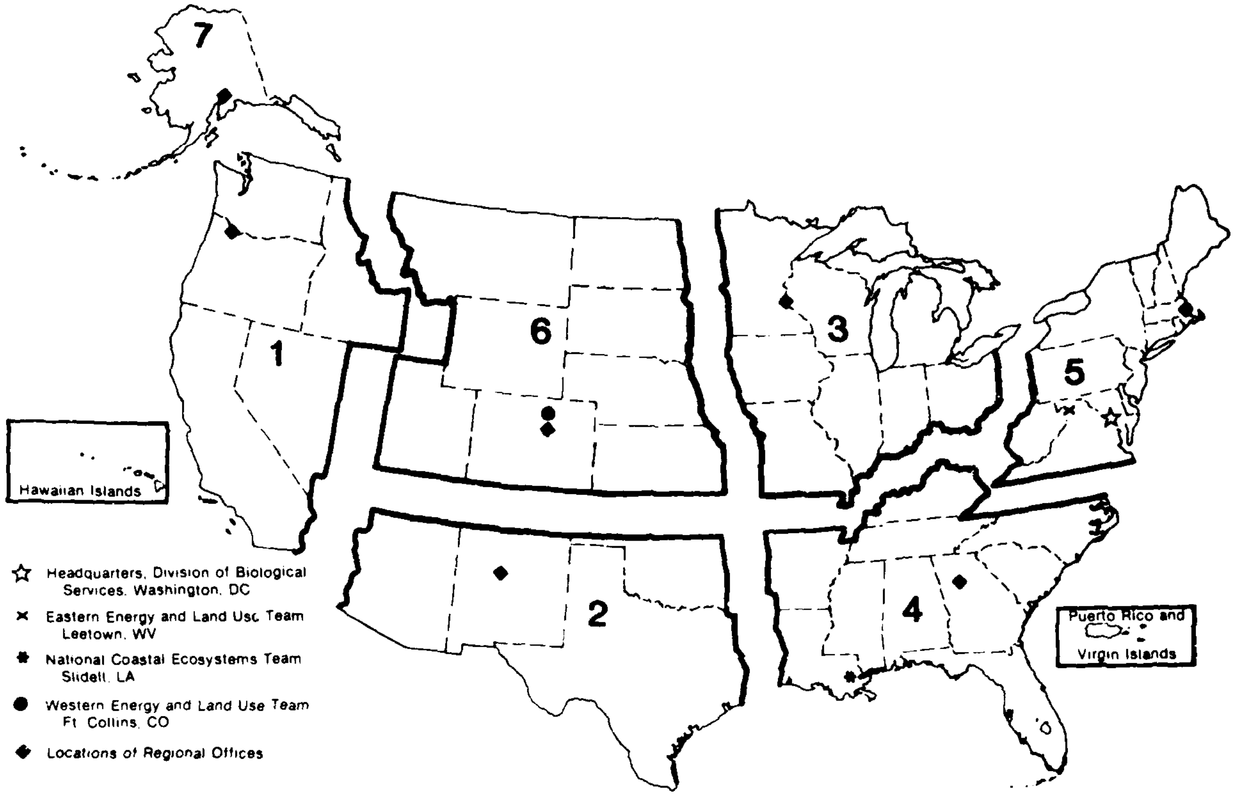

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